BACKGROUND OF THE INVENTION

Present day motor vehicles employ internal combustion engines operating with petroleum based fuels. In the future internal combustion engines will, in all likelihood, be replaced with other power sources such as hydrogen based fuel cells portrayed by Argonne National laboratory in "Fuel reformer brings practical electric cars closer," in which development of a partial oxidation methanol reformer is discussed. A state of the art process and apparatus for methanol reforming to form hydrogen is depicted in U.S. Patent No. 5,989,503. Energy for this reforming is furnished from external heat from an oil heating circuit. Several state of the art methods for forming hydrogen employing a steam reformer are described in U.S. Patents Nos. 5,997,594, 5.639,431, and 5,938,800 converting fuel to form hydrogen. Several state of the art methods for forming hydrogen employing a partial oxidation reformer are disclosed in U.S. Patents Nos. 5,942,346 and 4,789,540 for converting fuel to form hydrogen. The hydrogen will be used to supply power for the motor vehicles and to form a water vapor which is pollution free. The problem with hydrogen powered vehicles is apparently the lack of a low cost practical mobile supply of hydrogen and insufficient range of distance. A mobile supply of hydrogen gas containing carbon monoxide and carbon dioxide is supplied from a fuel by a mobile reformer. The gas from the reformer commonly contains toxic carbon monoxide which should conceivably be converted to non toxic carbon dioxide. The resulting hydrogen gas is often separated by a membrane permeable to hydrogen to provide power to a fuel cell located in a vehicle.

It is therefore an object of this invention to obviate many of the limitations or disadvantages of the prior art.

The present concern is about producing hydrogen from a gas containing carbon monoxide derived from fuel reforming without employing a hydrogen permeable membrane.

A distinct object of this invention is to dissolve carbon monoxide contained in a gas derived from fuel reforming in a solvent to thus extract carbon monoxide from the gas.

Still another object of this invention is to provide electrical heat to catalysts employed in forming hydrogen.

Yet another object of this invention is to provide hydrogen to power a fuel cell located within a vehicle to generate electrical power.

With the above and other objects in view, this invention relates to the novel features and alternatives and combinations presently described in the brief description of the invention.

APPLICATIONS AND BACKGROUND OF THE INVENTION

Several solvents to dissolve carbon monoxide are disclosed in the Merck index, eighth edition, 1968, pages 208-209. Inorganic solvents include a concentrated solvent of NH_4OH in addition to cuprous chloride in HCl and organic solvents such as ethyl acetate, Dichloromethane and acetic acid. Also disclosed are organic solvents including methanol and ethanol. Solvents capable of dissolving carbon monoxide is selected from the group consisting of ethanol and methanol including an individual or a combination thereof. Methanol or ethanol, can be employed as a solvent capable of dissolving carbon monoxide, supplied from a fuel tank located in a vehicle. Methanol or ethanol containing dissolved carbon monoxide can be employed to supply fuel to a reformer to produce hydrogen. Consequently a gas containing carbon monoxide can be substantially freed of carbon monoxide by employing a solvent capable of dissolving carbon monoxide. The gas, substantially free of carbon monoxide, likely contains carbon dioxide and can be scrubbed to remove carbon dioxide

One example of scrubbing a gas containing carbon dioxide is described on pages 126 and 128 in Chemical Process Industries, second edition, authored by R. N. Shreve, in which sodium carbonate is employed for scrubbing a flue gas containing carbon dioxide to form water soluble sodium bicarbonate. The solution containing sodium bicarbonate is then heated to produce concentrated gaseous carbon dioxide and a solution containing sodium carbonate to be recycled. Shreve, *op.cit.* pages 131 and 132, describes a method to scrub a gas containing carbon dioxide in an aqueous solution of mono ethanolamine, to provide a solution, in which the carbon dioxide is removed from the aqueous solution to produce carbon dioxide as a gas. The solution for scrubbing and removing carbon dioxide is often selected from the group consisting of aqueous bases and aqueous salts including an individual or combination of these. In addition, there are also miscellaneous scrubbing methods to remove carbon dioxide from a gas containing carbon dioxide employing adsorbents. Adsorbents for scrubbing and removing carbon dioxide may be selected from the group consisting of silica gel and alumina including an individual or mixtures thereof.

Shifting a gas obtained from a fuel reformer containing hydrogen and carbon monoxide is customarily achieved with water as steam to shift carbon monoxide to carbon dioxide and hydrogen. Steam is reacted with carbon monoxide to convert carbon monoxide, reversibly, to carbon dioxide and hydrogen, as described by Shreve, *op. cit.* , page 136.

BRIEF DESCRIPTION OF THE INVENTION

The present invention, in its broadest aspect, is a method to form hydrogen by subjecting fuel to a fuel reformer. Gas from a fuel reformer and steam reforming, containing hydrogen and remaining carbon monoxide, is scrubbed with a solvent capable of dissolving remaining carbon monoxide. The solvent, containing dissolved carbon monoxide, is separated from the gas and vaporized and combined with water vapor fed to a fuel reformer wherein the vapor is catalyzed to form hydrogen. The catalysts are heated electrically to provide energy to form hydrogen. Upon scrubbing the reformer gas containing hydrogen is substantially devoid of carbon monoxide. The resulting gas generally contains solvent and is scrubbed with water to dissolve solvent in water and provide gas substantially free of solvent. The gas substantially free of solvent is separated from water containing dissolved solvent. The water containing dissolved solvent is distilled to form water vapor containing solvent vapor for addition to solvent vapor previously formed by evaporation of the solvent containing dissolved carbon monoxide. The resulting gas, substantially free of carbon monoxide and solvent, usually contains carbon dioxide is then scrubbed to remove carbon dioxide from the gas.

Characteristics of the invention include;

Production of hydrogen substantially devoid of carbon gases.

A solvent is converted to form hydrogen and carbon monoxide by a fuel reformer.

Providing a solvent such as ethanol or methanol containing previously dissolved carbon monoxide in a solvent subject to reforming to create a gas containing hydrogen.

Vaporizing the solvent containing dissolved carbon monoxide from sensible heat of the gas containing remaining carbon monoxide to form solvent vapor containing carbon monoxide.

Combining vapor containing water vapor to the solvent vapor containing carbon monoxide.

Conversion of carbon monoxide, contained in reformer gas, to hydrogen and carbon dioxide utilizing water vapor.

Water vapor and solvent vapor are subjected to temperature control.

Hydrogen may be concentrated by an adsorbent selected from the group consisting of activated charcoal and structured carbon including an individual or a combination thereof.

Fuel reformer is restrained in a container located in a vehicle.

Providing hydrogen from a reformer, separated from carbon gases, to produce hydrogen to power a fuel cell located in a vehicle to generate electrical power regulated upon demand.

BRIEF DESCRIPTION OF THE DRAWINGS

The features that are considered characteristic of this invention are set forth in the appended claims. This invention, however, both as to its origination and method of operations as well as additional advantages will best be understood from the following description when read in conjunction with the accompanying drawings in which:

FIG. 1 is a flow sheet denoting the invention as set forth in the appended claims.

FIG. 2 is a flow sheet denoting a method to recover solvent within a gas.

FIG. 3 is a flow sheet denoting a method to remove carbon dioxide from a gas.

FIG. 4 is a flow sheet denoting a use of an adsorbent to remove solvent within a gas.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The flow diagram of **Fig. 1** illustrates the general preferred embodiment of the present invention. In the diagram, rectangles represent stages, operations or functions of the present invention and not necessarily separate components. Details within each stage, operations or functions are not shown. Arrows indicate direction of flow of material in the method.

Referring to **Fig. 1,** a method is depicted to supply hydrogen from a reformer. Vapor **10,** combined with vapor of solvent and water **10A** is transported to a reformer containing a catalyst **12,** heated by electrical heart **16** to produce reformer gas **14.** The reformer gas **14** is advanced to shift reaction stage containing a catalyst **18,** heated by electrical heart **20** to shift carbon monoxide into carbon dioxide and hydrogen. The resulting gas containing carbon dioxide unreacted carbon monoxide and hydrogen **22** is advanced to heat exchange stage **24** to vaporize solvent **32** to form vapor **10** containing solvent and carbon monoxide. The gas of reduced sensible heat **26** is mingled with a solvent **30** to dissolve carbon monoxide stage **28** to form solvent and dissolved carbon monoxide **32**. and a gas containing solvent within gas **34**. The gas containing carbon dioxide, unreacted carbon monoxide and hydrogen **22** contains considerable sensible heat which is reduced in heat exchange stage **24** to form gas of reduced sensible heat **26.** Gas of reduced sensible heat containing unreacted carbon monoxide **26** is dissolved in solvent to remove unreacted carbon monoxide from the gas and as a result produce a gas containing solvent within gas **34.** Catalysts are routinely heated by electrical elements with power supplied from fuel cells.

Catalysts for reforming and catalysts for steam shifting are often combined and electrically heated elements by a single electrically source.

Referring to **Fig. 2,** a supply of a gas containing solvent within gas **34** is subjected to scrub in water stage **36** to scrub solvent from the gas and produce gas devoid of solvent **38** and a water solution of dissolved solvent **40**. The water solution of dissolved solvent **40** is transported to a distill stage **42**. Upon distillation, vapor of solvent and water **10A** is formed and following separating a raffinate **44** results. The raffinate **44** is transported to a water cooler stage **46** where air **48** is employed to cool water and discharge air **50** and cooled raffinate **52** transported to scrub in water stage **36**. The water cooler stage **46** is generally a cooling tower wherein water is evaporated to humidify the air **50**.

Referring to **Fig. 3,** a supply of a gas devoid of solvent **38** is subjected to scrub in solution stage **52** to scrub carbon dioxide from the gas and produce a gas devoid of carbon dioxide **56** and a solution of dissolved carbon dioxide **58**. The solution containing carbon dioxide **58** is transported to heat solution stage **60**. Upon heating carbon dioxide **62** is released and a solution substantially devoid of carbon dioxide **64** results. The solution **64** is transported to cooler stage **66** where air **68** is employed to cool the solution and discharge air **70** and cooled solution **54** is transported to scrub in solution stage **52**. The solution cooler stage **66** is generally a cooling tower wherein solution containing water is evaporated to humidify air **70.**

Referring to **Fig. 4,** a supply of a gas containing solvent within gas **34** is subjected to scrub in adsorbent stage **72** to scrub solvent from the gas and produce gas devoid of solvent **76** and an adsorbent containing solvent **78**. The adsorbent containing solvent **78** is heated in heat adsorbent stage **80**. Upon heating, vapor of solvent **82** is released from the adsorbent and adsorbent substantially devoid of vapor **86** results. The adsorbent **86** is cooled in cooler stage **86** where air **88** is employed to cool adsorbent and discharge air **90** and cooled adsorbent **74** employed in scrub in adsorbent stage **72**. The scrub in adsorbent stage **72** is customarily operated in batch mode and the employed adsorbent consequently remains stationary. Solvent contained within the gas is thus absorbed by the adsorbent, and the adsorbent heated, to vaporize the solvent followed by release the vapor to furnish adsorbent for reuse.